Mapping Structure Flooding and Damages using HEC-FDA and GIS

Douglas Symes
Regional Economist
Honolulu District

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Objectives

- Check HEC-FDA without-project model for reasonableness – does it make sense?
- Provide feedback to aid the iterative planning and design processes
- Highlight data entry errors
- Provide sub-reach detail of without-project impact or with-project plan performance

Palai Stream Flood Damage Reduction Feasibility Study

- Located in Hilo, Hawaii
- Small project, 143 structures
- Section 205, Continuing Authorities Program
- Stream dry except during moderate to heavy rain

November 2000 Flood – a 50 year event

- Floodwaters overtopped 3’ diameter culvert under Kanoelehua Avenue, forming a ford.
- Residential flooded >4 feet over first floor elevation (Awaphui Street) requiring rescue by boat.
- 1 to 4 feet of flooding reported by other homes and businesses.

Palai Stream: Structure Inventory – Core Components

- 120 Residential Structures
  - $8M total depreciated replacement value (DRV)
  - $66,000 average DRV
- 23 Commercial Structures
  - $8M total DRV
  - $351,000 average DRV
- 120 Residential Autos at Risk
  - $1.2M total used market value
  - $9,700 average used market value

Palai Stream:
Additional Damage Categories

- (calculated with HEC-FDA)
  - Residential and Commercial Contents
  - Yards and Outside Property
  - Emergency Services

- (calculated outside HEC-FDA)
  - Flood Insurance Cost Reduction
  - Travel Delay Cost Reduction

New and Old Construction

HEC-FDA Results:

Do we have a project?

Equivalent Annual Damage Analysis

File Help

Palai
Equivalent Annual Damage by Damage Categories and Damage Reaches
for the Without (Without project condition) plan
(Damage in $1,000's)

Discount Rate: 5.125
Analysis Period: 50 Years
Plan was calculated with Uncertainty

Stream Name	Stream Description	Damage Reach Name	Damage Reach Description	Equivalent Annual Damage or Damage Categories					Total Damage
				AUTO	COM	RES	RES_E	RES_Y	
Palai Stre	Palai Stream	P01	Palai sta 7.454 to	496.75	1636.59	522.65	44.08	222.40	2922.47
		P02	Palai sta 7706.03	76.80	0.00	283.92	22.55	44.09	427.37
		P03	Palai sta 10424.57	40.03	0.00	73.58	5.18	31.68	150.46
		P04	Palai sta 13597.02	86.04	0.00	424.19	22.78	75.14	608.15
		P05	Palai sta 17199.0	0.00	0.00	0.00	0.00	0.00	0.00
	Total for strea			699.62	1636.59	1304.34	94.59	373.30	4108.45

***** - Computations have not been completed.
+ - Something has changed and computations need to be redone.

Do we have a project? First reactions…

- $4M without-project equivalent annual damages (EAD) will potentially support a $70M project . PM = ☺
- With only 143 structures, $4M EAD = $29K damages per structure per year. Seems unreasonably high. PM = ☹

Without-Project Performance?

- Long-term risk = 100%
- Conditional non-exceedance probability = 0%

Project Performance

File Help

Palai Project Performance
by Plans and Damage Reaches by Analysis Year 2008
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedar Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expecte	10	25	50	10%	4%	2%	1%	.4%	.2%
Without	Palai Stream	P01	Palai sta 7.454 to 7706.03	35.50	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		P02	Palai sta 7706.03 to 1042	71.50	0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		P03	Palai sta 10424.57 to 135	93.50	0.9990	0.9890	1.0000	1.0000	1.0000	0.0040	0.0033	0.0024	0.0019	0.0012	0.0007
		P04	Palai sta 13597.02 to 171		0.9990	0.9940	1.0000	1.0000	1.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
		P05	Palai sta 17199.04 to 200		0.9990	0.9990	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

***** - Computations have not been completed.
+ - Something has changed and computations need to be redone.

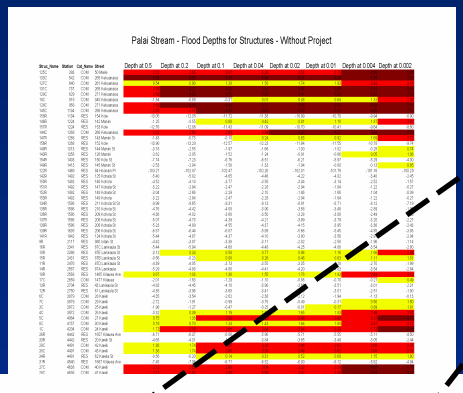
What HEC-FDA standard reports do not tell us:

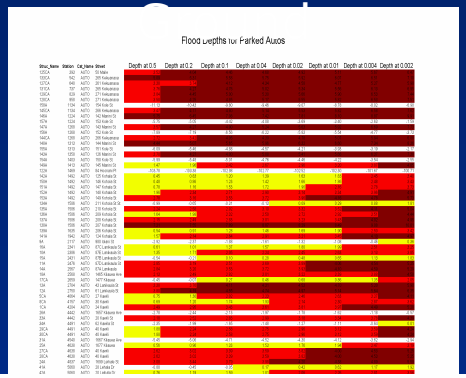
- Is damage concentrated in small areas or evenly spread through each reach?
- Which individual structures generate the most damages in the model?

The answers are in the FDA_StrucDetail.out file…

Spreadsheet Graphic Flooding > FFE

Spreadsheet Graphic Flooding >

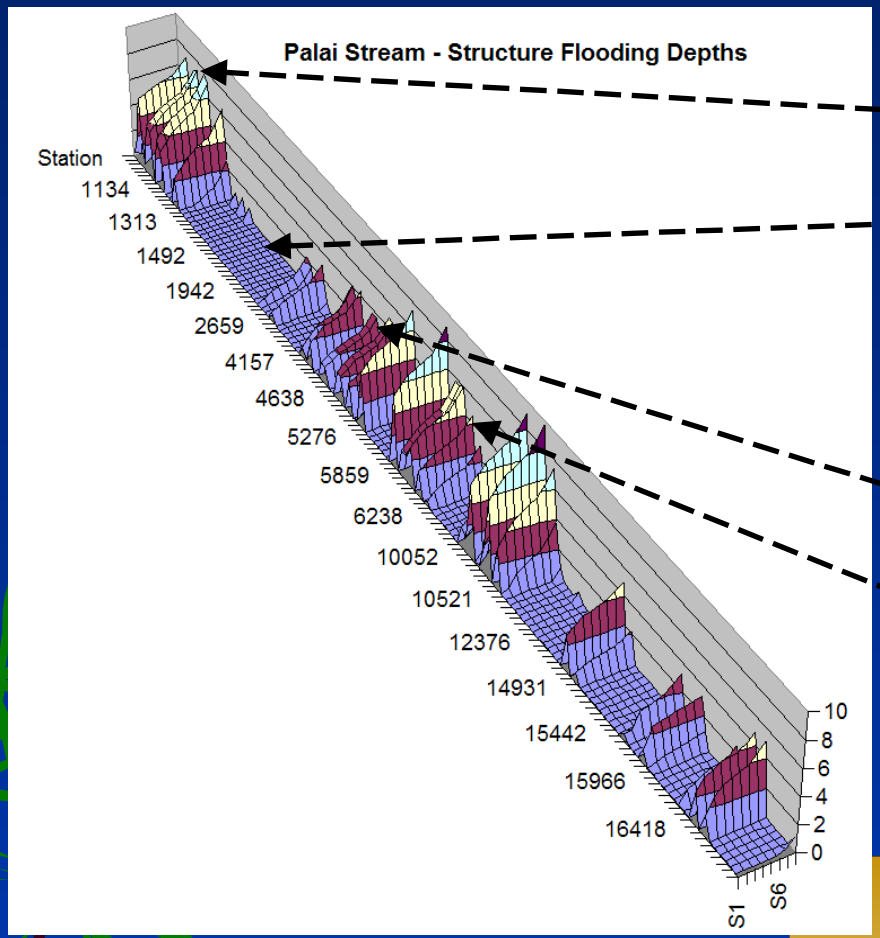


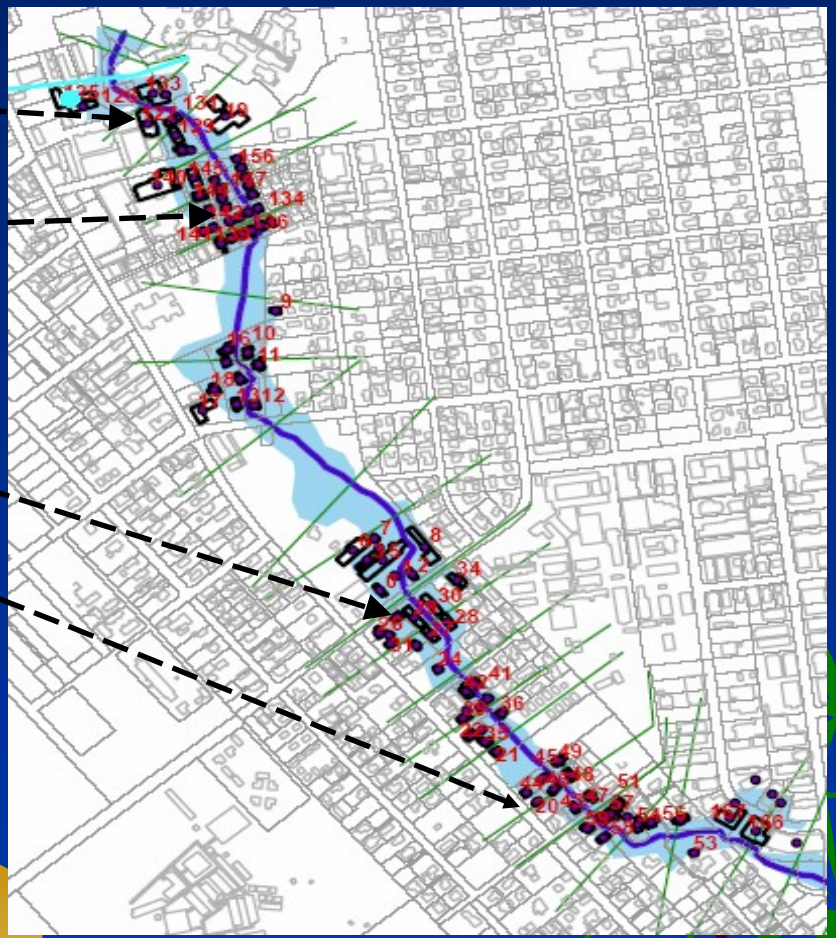


Struc_Name	Station	Cat_Name	Street	Depth at 0.5	Depth at 0.2	Depth at 0.1	Depth at 0.04	De
125C	393	COM	50 Maile	2.13	2.65	3.07	3.29	
133C	542	COM	265 Kekuanaoa	5.28	5.50	5.77	5.94	
127C	640	COM	261 Kekuanaoa	0.54	0.90	1.28	1.50	
131C	737	COM	265 Kekuanaoa	3.76	4.27	4.76	5.02	
129C	829	COM	271 Kekuanaoa	3.59	4.20	4.75	5.05	
19C	915	COM	345 Kekuanaoa	-1.54	-0.89	-0.31	0.01	
128C	958	COM	271 Kekuanaoa	3.58	4.25	4.85	5.17	
145C	1134	COM	266 Kekuanaoa	2.97	3.67	4.30	4.64	
158R	1134	RES	154 Kole	-13.05	-12.35	-11.72	-11.38	
146R	1224	RES	142 Manini	-1.25	-0.55	0.08	0.42	
157R	1224	RES	153 Kole	-12.76	-12.06	-11.43	-11.09	
144C	1268	COM	266 Kekuanaoa	2.22	2.92	3.55	3.89	
147R	1268	RES	143 Manini Sr	-1.43	-0.73	-0.10	0.24	
156R	1268	RES	152 Kole	-13.90	-13.20	-12.57	-12.23	
148R	1313	RES	144 Manini St	-3.18	-2.55	-1.97	-1.66	
143R	1358	RES	126 Manini	-2.62	-2.05	-1.52	-1.24	
154R	1403	RES	150 Kole St	-7.74	-7.23	-6.76	-6.51	
149R	1413	RES	145 Manini St	-2.53	-2.04	-1.58	-1.33	
122R	1469	RES	84 Hoonani Pl	-103.27	-102.87	-102.47	-102.26	

flooding.

Same data in 3D Excel Chart

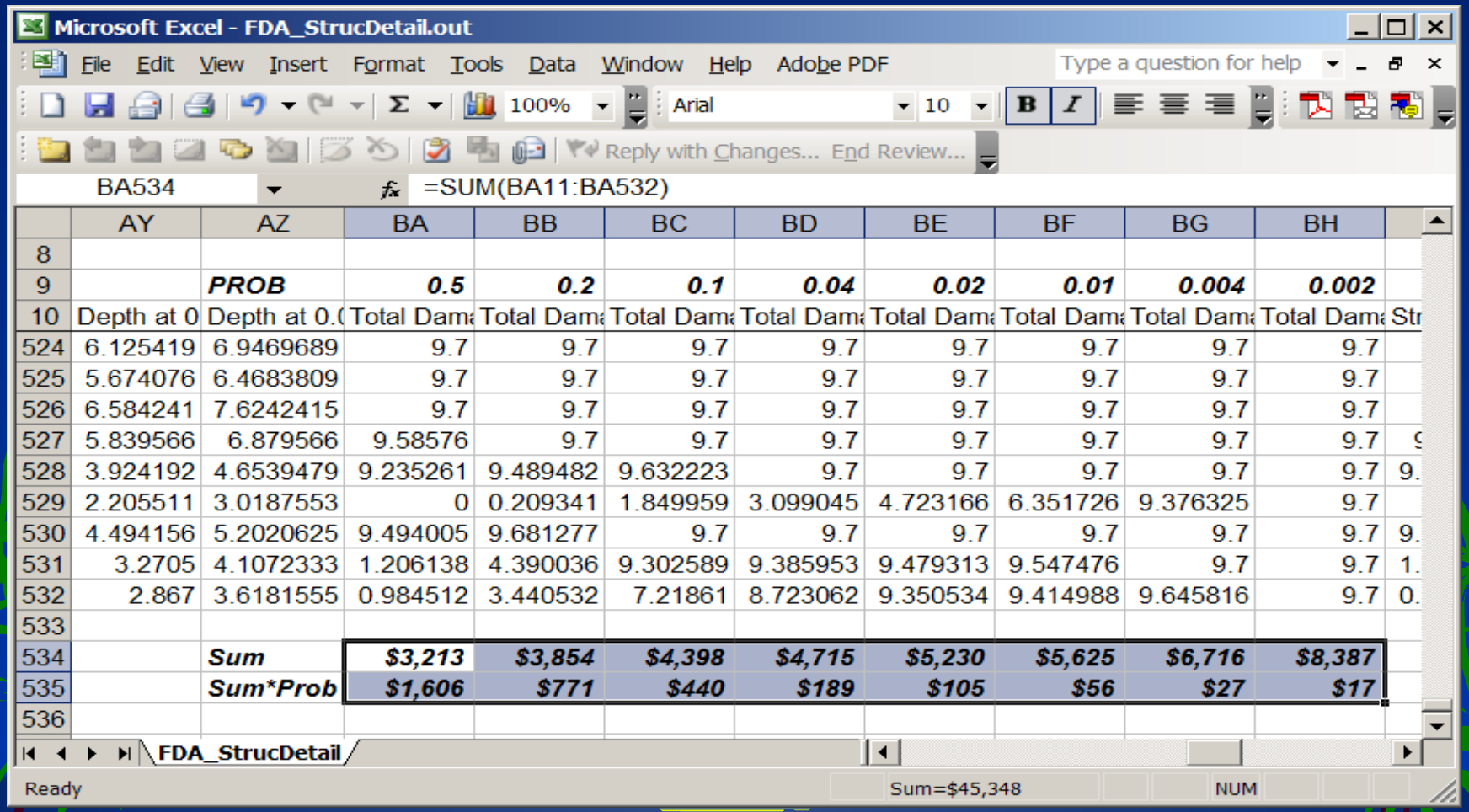




More answers...

Test: Sum damages by event and multiply by probability.

Conclusion: Most damages contributed by frequent events.



Microsoft Excel - FDA_StrucDetail.out

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Reply with Changes... End Review...

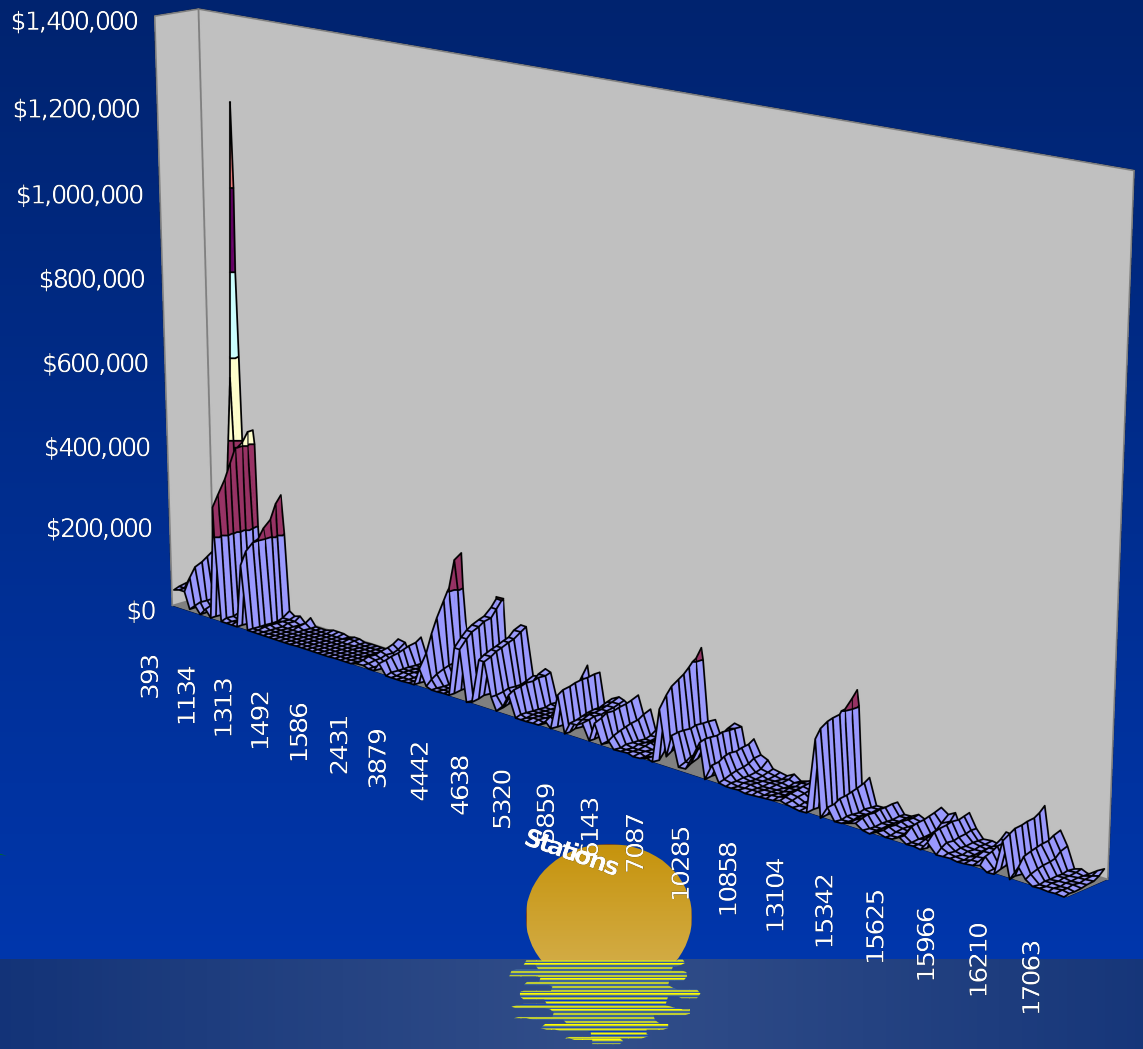
BA534 — =SUM(BA11:BA532)

	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH
8										
9		***PROB***	***0.5***	***0.2***	***0.1***	***0.04***	***0.02***	***0.01***	***0.004***	***0.002***
10	Depth at 0	Depth at 0.(	Total Dama	Total Dama	Total Dama	Total Dama	Total Dama	Total Dama	Total Dama	Total Dama	Str
524	6.125419	6.9469689	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	
525	5.674076	6.4683809	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	
526	6.584241	7.6242415	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	
527	5.839566	6.879566	9.58576	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9
528	3.924192	4.6539479	9.235261	9.489482	9.632223	9.7	9.7	9.7	9.7	9.7	9.
529	2.205511	3.0187553	0	0.209341	1.849959	3.099045	4.723166	6.351726	9.376325	9.7	
530	4.494156	5.2020625	9.494005	9.681277	9.7	9.7	9.7	9.7	9.7	9.7	9.
531	3.2705	4.1072333	1.206138	4.390036	9.302589	9.385953	9.479313	9.547476	9.7	9.7	1.
532	2.867	3.6181555	0.984512	3.440532	7.21861	8.723062	9.350534	9.414988	9.645816	9.7	0.
533											
534		***Sum***	***$3,213***	***$3,854***	***$4,398***	***$4,715***	***$5,230***	***$5,625***	***$6,716***	***$8,387***	
535		***Sum*Prob***	***$1,606***	***$771***	***$440***	***$189***	***$105***	***$56***	***$27***	***$17***	
536											

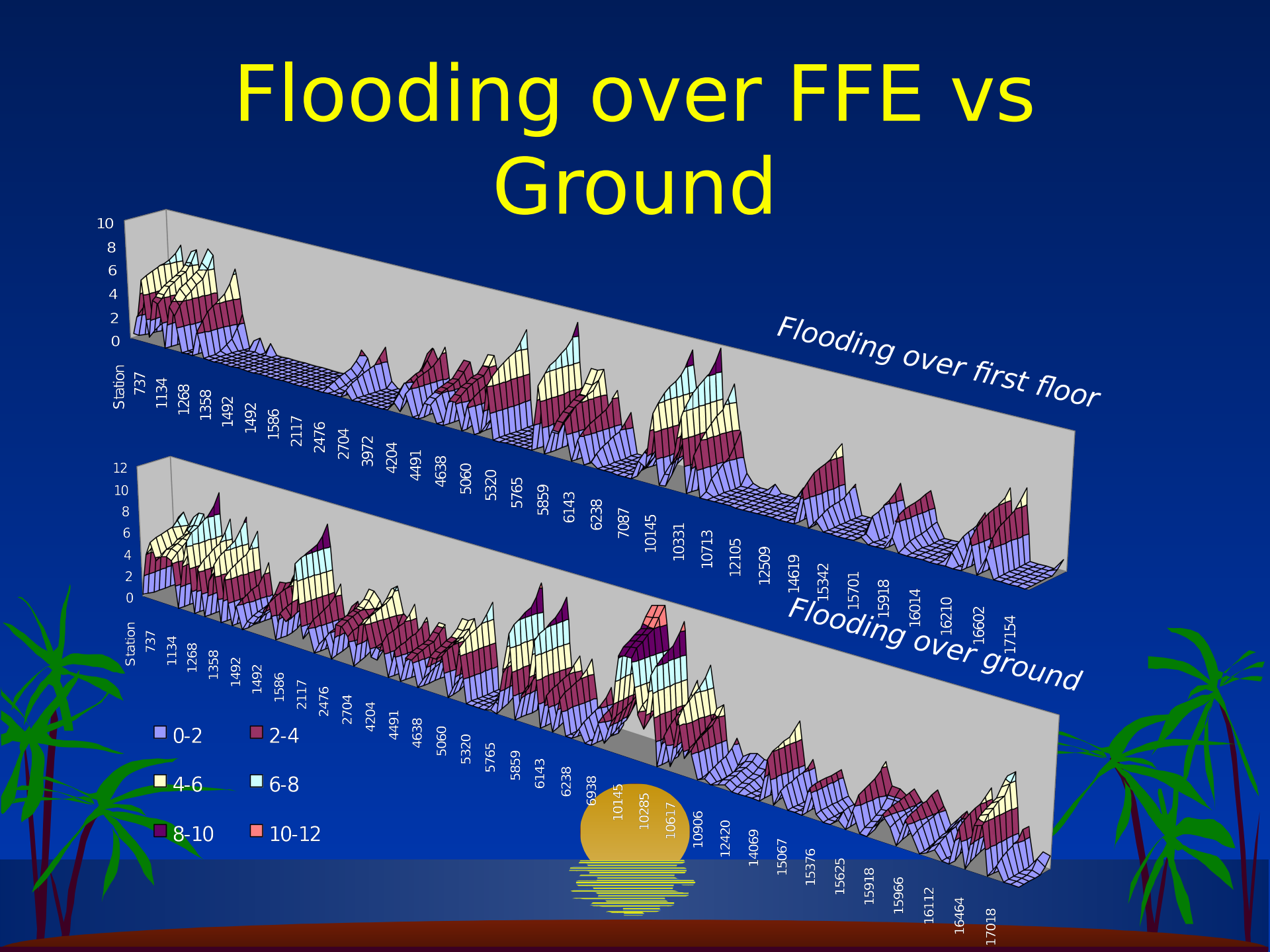
FDA_StrucDetail

Ready — Sum=$45,348 — NUM

Total Damages by Structure (sorted by station) by Frequency



Flooding over FFE vs Ground



Palai Stream...

- Does the without-project model make sense?
  - No.
- Action:
  - Hydrology is currently being revised to better reflect the experience of residents and businesses.
- Result:
  - Improved quality of planning and design process.

Limitations – Spreadsheet Graphic

- No risk and uncertainty
- Only 3 colors or depth ranges
- Text can get very small for large floodplains
- Focuses only on structures – ignores ecological impacts

Wailupe Stream, Island of Oahu

- East Honolulu neighborhood
- General Reevaluation Report
- 893 residential structures
- 39 commercial structures

Limitations – 3D Excel Charts

- No risk and uncertainty
- Only usable for <200 structures per chart
- Does not show structure name, address, or other database info

Step-by-step Instructions

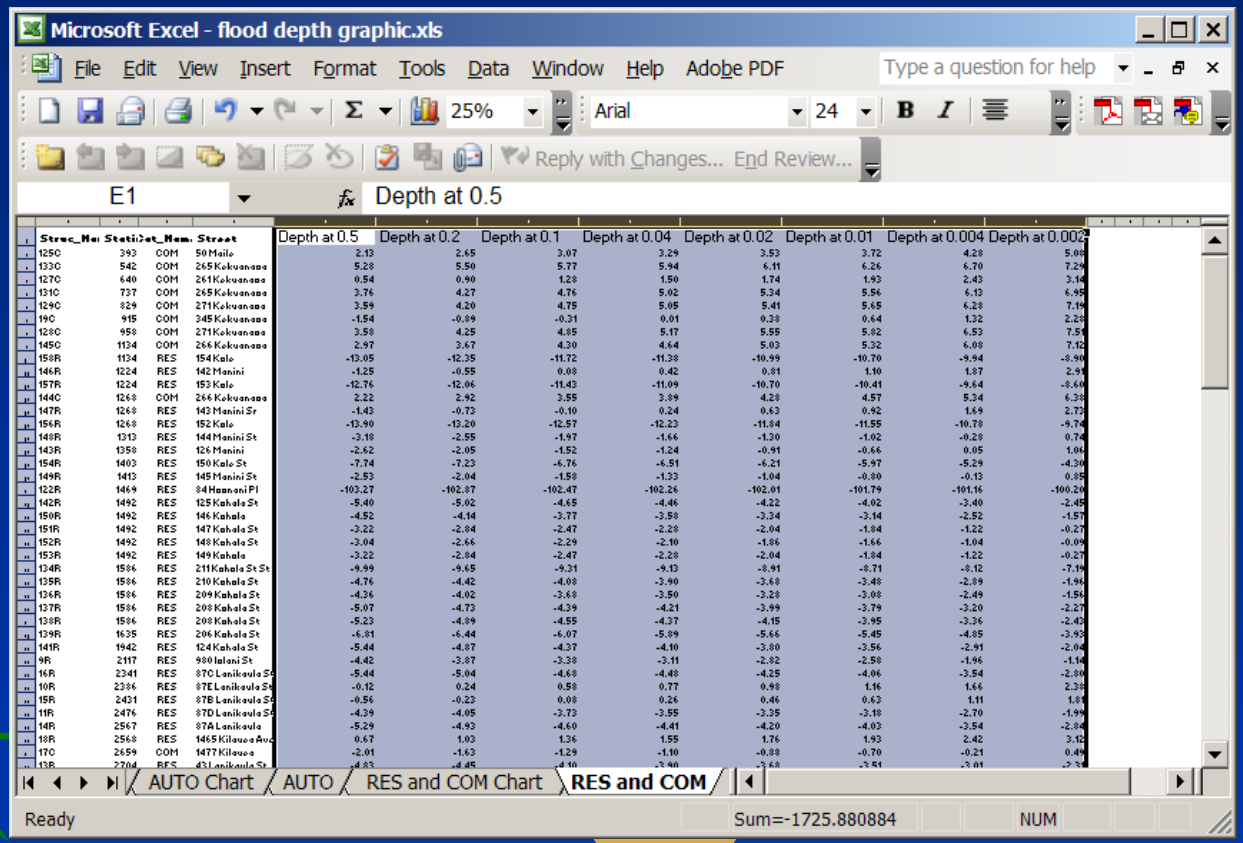
- Open FDA_StrucDetail.out file in Excel.
- Rename and save as an Excel Workbook.
- Add a new worksheet and copy the following columns to it:

  Column A: Struc_Name
  Column D: Station
  Column G: Cat_Name
  Column I: Street
  Columns AS – AZ: Flood depth, 0.5 – 0.002 Prob.

Step-by-step instructions (continued)

- Sort by damage categories and then delete all rows except for residential and commercial structures
- Sort by station
- Select the data area
- Use *CONDITIONAL FORMATTING* to color cells for different depths of flooding

Select data area...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Depth at 0.5 Depth at 0.2 Depth at 0.1 Depth at 0.04 Depth at 0.02 Depth at 0.01 Depth at 0.004 Depth at 0.002
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Ready
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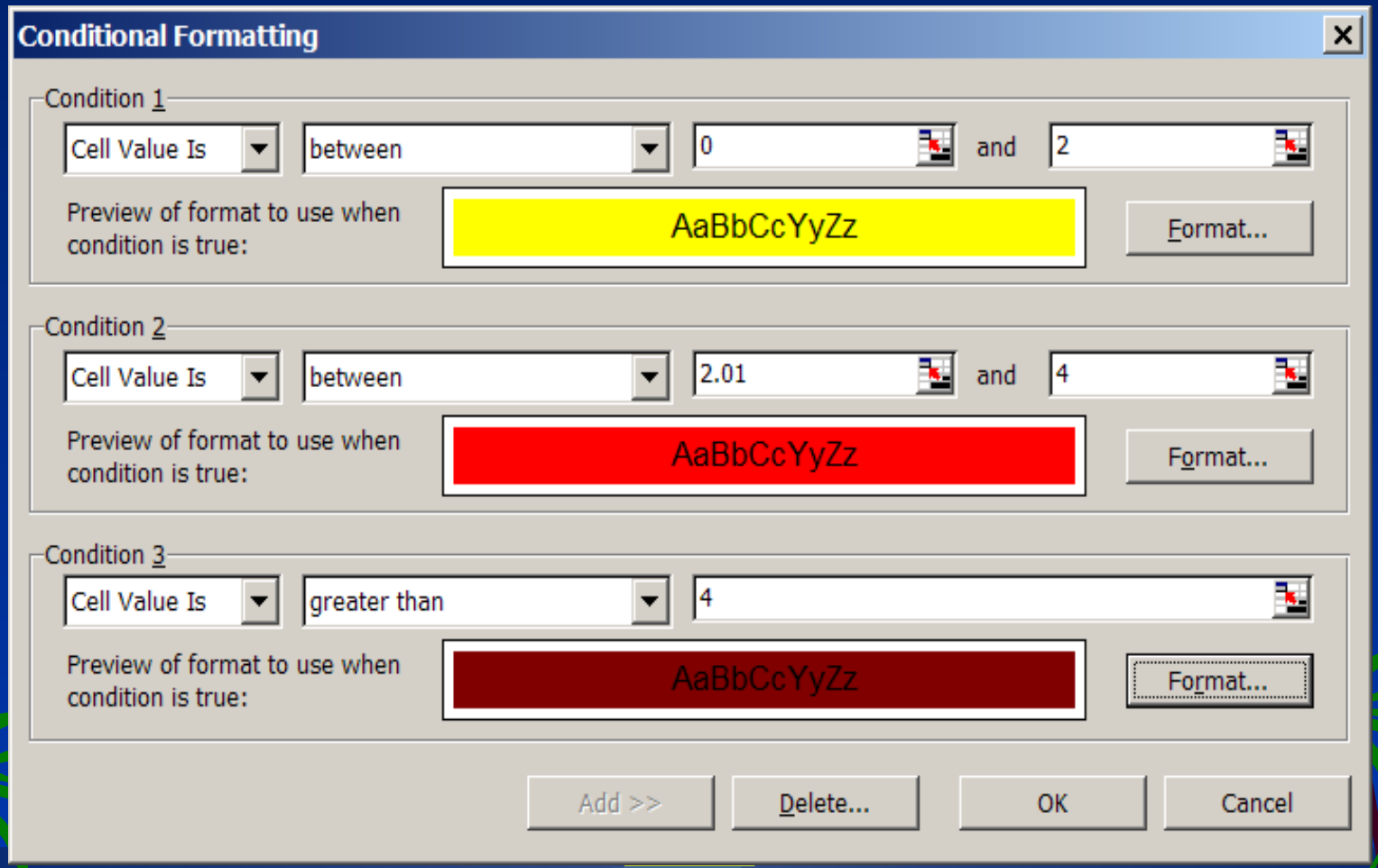
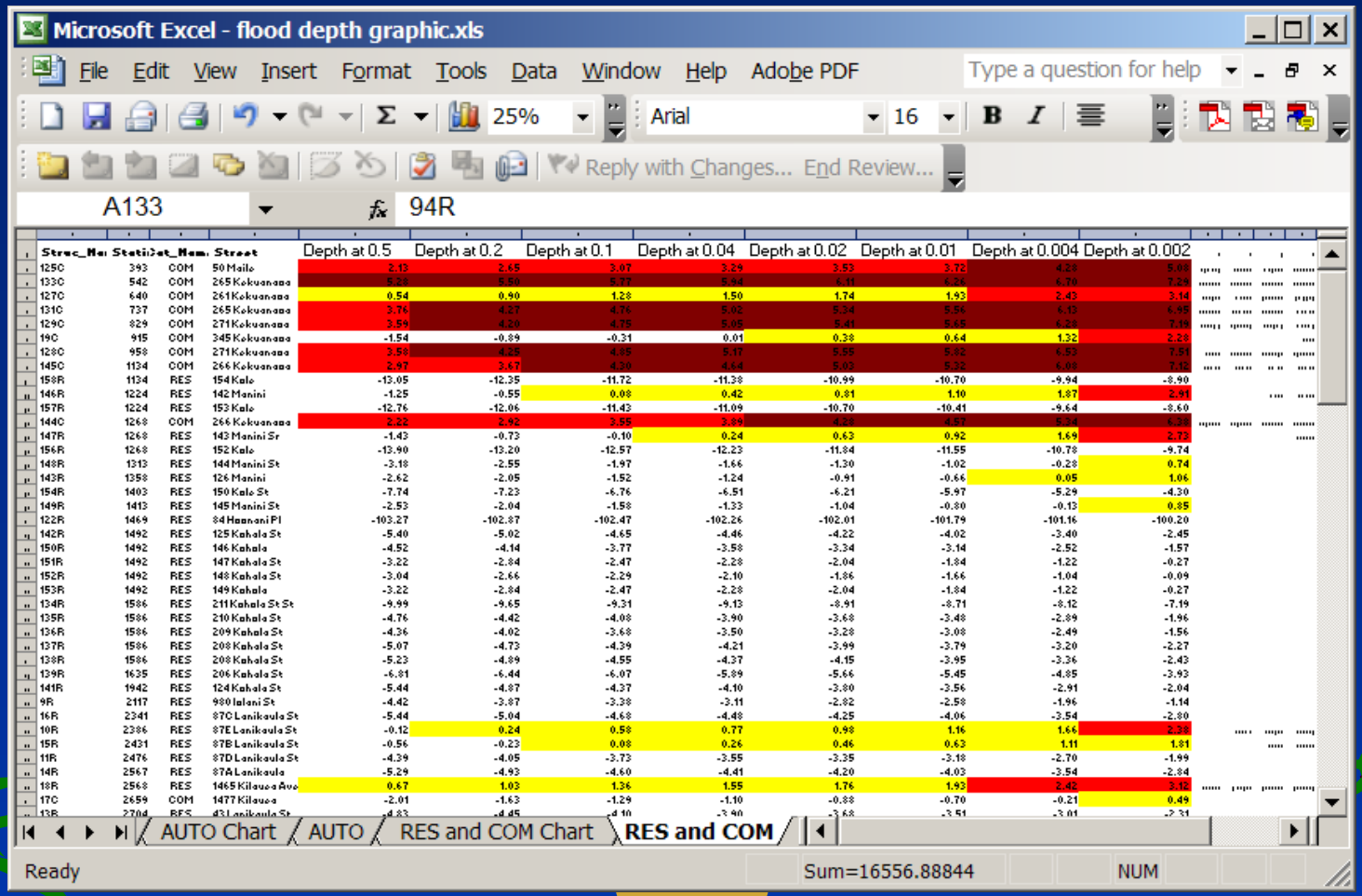
NUM

Add conditional formatting...



Result...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A133
94R
Strec_Nu Stati Set_Num Street Depth at 0.5 Depth at 0.2 Depth at 0.1 Depth at 0.04 Depth at 0.02 Depth at 0.01 Depth at 0.004 Depth at 0.002
125C 393 COM 50 Maile 2.13 2.65 3.07 3.29 3.53 3.72 4.28 5.69
133C 542 COM 265 Kekuanaoa 5.28 5.60 5.72 5.94 6.18 6.34 6.70 7.28
127C 640 COM 261 Kekuanaoa 0.54 0.90 1.28 1.50 1.74 1.93 2.43 3.14
131C 737 COM 265 Kekuanaoa 3.76 4.27 4.76 5.02 5.34 5.56 6.13 6.95
129C 829 COM 271 Kekuanaoa 3.59 4.20 4.75 5.05 5.41 5.65 6.22 7.19
19C 915 COM 345 Kekuanaoa -1.54 -0.89 -0.31 0.01 0.38 0.64 1.32 2.28
128C 958 COM 271 Kekuanaoa 3.58 4.25 4.85 5.17 5.55 5.82 6.53 7.51
145C 1134 COM 266 Kekuanaoa 2.97 3.67 4.30 4.64 5.03 5.32 6.08 7.12
158R 1134 RES 154 Kalo -13.05 -12.35 -11.72 -11.38 -10.99 -10.70 -9.94 -8.90
146R 1224 RES 142 Manini -1.25 -0.55 0.08 0.42 0.81 1.10 1.87 2.91
157R 1224 RES 153 Kalo -12.76 -12.06 -11.43 -11.09 -10.70 -10.41 -9.64 -8.60
144C 1268 COM 266 Kekuanaoa 2.22 2.92 3.55 3.89 4.28 4.57 5.34 6.38
147R 1268 RES 143 Manini Sr -1.43 -0.73 -0.10 0.24 0.63 0.92 1.69 2.73
156R 1268 RES 152 Kalo -13.90 -13.20 -12.57 -12.23 -11.84 -11.55 -10.78 -9.74
148R 1313 RES 144 Manini St -3.18 -2.55 -1.97 -1.66 -1.30 -1.02 -0.28 0.74
143R 1358 RES 126 Manini -2.62 -2.05 -1.52 -1.24 -0.91 -0.66 0.05 1.06
154R 1403 RES 150 Kalo St -7.74 -7.23 -6.76 -6.51 -6.21 -5.97 -5.29 -4.30
149R 1413 RES 145 Manini St -2.53 -2.04 -1.58 -1.33 -1.04 -0.80 -0.13 0.85
122R 1469 RES 84 Haonani Pl -103.27 -102.87 -102.47 -102.26 -102.01 -101.79 -101.16 -100.20
142R 1492 RES 125 Kahala St -5.40 -5.02 -4.65 -4.46 -4.22 -4.02 -3.40 -2.45
150R 1492 RES 146 Kahala -4.52 -4.14 -3.77 -3.58 -3.34 -3.14 -2.52 -1.57
151R 1492 RES 147 Kahala St -3.22 -2.84 -2.47 -2.28 -2.04 -1.84 -1.22 -0.27
152R 1492 RES 148 Kahala St -3.04 -2.66 -2.29 -2.10 -1.86 -1.66 -1.04 -0.09
153R 1492 RES 149 Kahala -3.22 -2.84 -2.47 -2.28 -2.04 -1.84 -1.22 -0.27
134R 1586 RES 211 Kahala St St -9.99 -9.65 -9.31 -9.13 -8.91 -8.71 -8.12 -7.19
135R 1586 RES 210 Kahala St -4.76 -4.42 -4.08 -3.90 -3.68 -3.48 -2.89 -1.96
136R 1586 RES 209 Kahala St -4.36 -4.02 -3.68 -3.50 -3.28 -3.08 -2.49 -1.56
137R 1586 RES 208 Kahala St -5.07 -4.73 -4.39 -4.21 -3.99 -3.79 -3.20 -2.27
138R 1586 RES 208 Kahala St -5.23 -4.89 -4.55 -4.37 -4.15 -3.95 -3.36 -2.43
139R 1635 RES 206 Kahala St -6.81 -6.44 -6.07 -5.89 -5.66 -5.45 -4.85 -3.93
141R 1942 RES 124 Kahala St -5.44 -4.87 -4.37 -4.10 -3.80 -3.56 -2.91 -2.04
9R 2117 RES 980 Iolani St -4.42 -3.87 -3.38 -3.11 -2.82 -2.58 -1.96 -1.14
16R 2341 RES 87C Lanikaula St -5.44 -5.04 -4.68 -4.48 -4.25 -4.06 -3.54 -2.80
10R 2386 RES 87E Lanikaula St -0.12 0.24 0.58 0.77 0.98 1.16 1.66 2.38
15R 2431 RES 87B Lanikaula St -0.56 -0.23 0.08 0.26 0.46 0.63 1.11 1.81
11R 2476 RES 87D Lanikaula St -4.39 -4.05 -3.73 -3.55 -3.35 -3.18 -2.70 -1.99
14R 2567 RES 87A Lanikaula -5.29 -4.93 -4.60 -4.41 -4.20 -4.03 -3.54 -2.84
18R 2568 RES 1465 Kilauea Ave 0.67 1.03 1.36 1.55 1.76 1.93 2.42 3.12
17C 2659 COM 1477 Kilauea -2.01 -1.63 -1.29 -1.10 -0.88 -0.70 -0.21 0.49
AUTO Chart AUTO RES and COM Chart RES and COM
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NUM

Questions?